

CLAIMS

We claim:

- 5 1. An apparatus for programming non-volatile storage elements, comprising:
 a programming circuit in communication with said non-volatile storage elements;
 and
 one or more verification selection circuits in communication with said non-
volatile storage elements, said one or more verification selection circuits cause a first
10 subset of said non-volatile storage elements to be subjected to coarse verification
concurrently while a second subset of said non-volatile storage elements are subjected to
fine verification.
2. An apparatus according to claim 1, further comprising:
15 a set of bit lines, each of said non-volatile storage elements are associated with at
least one of said bit lines, said one or more verification selection circuits include one
verification selection circuit for each of said bit lines.
3. An apparatus according to claim 1, wherein:
20 said one or more verification selection circuits include one verification selection
circuit for each non-volatile storage element of a subset of non-volatile storage elements.
4. An apparatus according to claim 1, wherein at least one of said one or
more verification selection circuits comprises:
25 a sense circuit in communication with a first non-volatile storage element;
 a programming mode indication circuit, in communication with said sense circuit,
providing an output indicating whether said first non-volatile storage element is in a

coarse programming mode or a fine programming mode based on said sense circuit; and
a selection circuit in communication with said programming mode indication
circuit, said selection circuit applies a coarse verification signal to said first non-volatile
storage element if said first non-volatile storage element is in said coarse programming
5 mode and applies a fine verification signal to said first non-volatile storage element if
said first non-volatile storage element is in said fine programming mode.

5. An apparatus according to claim 1, wherein at least one of said one or
more verification selection circuits comprises:
10 a storage unit, said storage unit storing data indicating whether a first non-volatile
storage element is in a coarse programming mode or a fine programming mode;
a first switch in communication with a first non-volatile storage element;
sense circuit connected to said first switch and providing an output to said storage
unit, said storage unit uses said output from said sense circuit to indicate whether said
15 first non-volatile storage element is in said coarse programming mode or said fine
programming mode; and
a second switch in communication with said storage unit and having an output
connected to said sense circuit, said second switch receiving a coarse reference signal and
a fine reference signal and providing either said coarse reference signal or said fine
20 reference signal at said output of said second switch in response to said storage unit.

6. An apparatus according to claim 5, wherein:
said non-volatile storage elements are flash memory devices.

25 7. An apparatus according to claim 5, wherein:
said coarse reference signal and said fine reference signal provide reference
currents.

8. An apparatus according to claim 5, wherein:
said coarse reference signal and said fine reference signal provide reference
voltages.

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9. An apparatus according to claim 5, wherein:
said coarse reference signal and said fine reference signal provide an indication of
discharge times.

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10. An apparatus according to claim 1, wherein:
said coarse verification and said fine verification are performed using a discharge
method.

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11. An apparatus according to claim 1, wherein:
said programming circuit includes a controller and a state machine; and
said programming circuit is separate from said one or more verification selection
circuits.

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12. An apparatus according to claim 1, wherein:
said non-volatile storage elements are multi-state flash memory devices.

13. An apparatus used during programming of a non-volatile storage element,
comprising:

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a sense circuit in communication with said non-volatile storage element;
a programming mode indication circuit providing an output indicating whether
said non-volatile storage element is in a coarse programming mode or a fine
programming mode based on said sense circuit; and

a first selection circuit in communication with said programming mode indication circuit, said first selection circuit applies a coarse reference signal to said non-volatile storage element if said non-volatile storage element is in said coarse programming mode and applies a fine reference signal to said non-volatile storage element if said non-volatile
5 storage element is in said fine programming mode.

14. An apparatus according to claim 13, wherein:
said coarse reference signal and said fine reference signal are from voltage
sources.

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15. An apparatus according to claim 13, wherein:
said coarse reference signal and said fine reference signal are from current
sources.

15 16. An apparatus according to claim 13, wherein:
said coarse reference signal and said fine reference signal indicate timing
information.

17. An apparatus according to claim 16, wherein:
20 said sense circuit includes electronic circuitry to perform a bit line discharge
analysis to determine if said non-volatile storage element is verified.

18. An apparatus according to claim 13, wherein:
said non-volatile storage element is a multi-state flash memory device.

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19. An apparatus according to claim 13, wherein:
said non-volatile storage element is a flash memory device.

20. An apparatus for programming non-volatile storage elements, comprising:
means for providing a programming signal to said non-volatile storage elements
as part of a programming process that includes a coarse programming phase and a fine
5 programming phase such that one or more of said non-volatile storage elements are in
said coarse programming phase while one or more of said non-volatile storage elements
are in said fine programming phase;

means for performing coarse verification for said one or more non-volatile storage
elements that are in said coarse programming phase without performing fine verification
10 for said one or more non-volatile storage elements that are in said coarse programming
phase; and

means for performing fine verification for said one or more non-volatile storage
elements that are in said fine programming phase without performing coarse verification
for said one or more non-volatile storage elements that are in said fine programming
15 phase.

21. An apparatus according to claim 20, wherein:

said means for performing coarse verification performs said coarse verification
for said one or more non-volatile storage elements that are in said coarse programming
20 phase while concurrently said means for performing fine verification performs said fine
verification for said one or more non-volatile storage elements that are in said fine
programming phase.

22. An apparatus according to claim 20, wherein:

25 said means for performing coarse verification and said means for performing fine
verification utilize a bit line discharge verification process.

23. An apparatus according to claim 20, wherein:
said non-volatile storage elements are multi-state flash memory devices.

24. A method for programming non-volatile storage elements, comprising:
5 providing a programming signal to said non-volatile storage elements, said step of
providing is part of a programming process that includes a coarse programming phase
and a fine programming phase such that one or more of said non-volatile storage
elements are in said coarse programming phase while one or more of said non-volatile
storage elements are in said fine programming phase; and
10 performing coarse verification for said one or more of said non-volatile storage
elements that are in said coarse programming phase while concurrently performing fine
verification for said one or more of said non-volatile storage elements that are in said fine
programming phase.

15 25. A method according to claim 24, wherein:
said step of providing includes providing said programming signal to a word line
common to at least a subset of said one or more of said non-volatile storage elements that
are in said coarse programming phase and said one or more of said non-volatile storage
elements that are in said fine programming phase.

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26. A method according to claim 24, wherein:
said non-volatile storage elements are flash memory devices.

27. A method according to claim 24, wherein:
25 said non-volatile storage elements are multi-state flash memory devices.

28. A method according to claim 24, further comprising:

using said coarse verification to determine when a particular non-volatile storage element completes said coarse programming phase and causing said particular non-volatile storage element to begin said fine programming phase.

5 29. A method according to claim 28, wherein:
 following said non-volatile storage element beginning said fine programming phase, said non-volatile storage element begins said fine verification.

 30. A method according to claim 28, wherein:
10 causing said particular non-volatile storage element to begin said fine programming phase includes raising a bit line voltage.

 31. A method according to claim 28, wherein said step of performing comprises:
15 performing coarse verification for said particular non-volatile storage element without performing fine verification for said particular non-volatile storage element, if said particular non-volatile storage element is determined to be in said coarse programming phase; and

 performing fine verification for said particular non-volatile storage element
20 without performing coarse verification for said particular non-volatile storage element, if said particular non-volatile storage element is determined to be in said fine programming phase.

 32. A method according to claim 24, wherein:
25 said coarse verification and said fine verification are based on a bit line discharge process.

33. A method according to claim 24, wherein said step of performing comprises:

pre-charging a first bit line based on a coarse pre-charge signal if a first non-volatile storage element is in said coarse programming phase;

5 pre-charging said first bit line based on a fine pre-charge signal if said first non-volatile storage element is in said fine programming phase;

applying a verify signal to a control gate for said first non-volatile storage element; and

allowing said bit line to discharge for a fixed period of time.

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34. A method according to claim 24, wherein said step of performing comprises:

pre-charging a first bit line for a first non-volatile storage element;

15 applying a verify signal to a control gate for said first non-volatile storage element;

determining a time for said bit line to discharge until said bit line reaches a predetermined value;

comparing a coarse compare value to said time, if said first non-volatile storage element is in said coarse programming phase; and

20 comparing a fine compare value to said time, if said first non-volatile storage element is in said fine programming phase.

35. A method according to claim 34, wherein:

25 said predetermined value is a first value if said first non-volatile storage element is in said coarse programming phase; and

said predetermined value is a second value if said first non-volatile storage element is in said fine programming phase.

36. A method performed when programming a non-volatile storage element, comprising:

determining whether said non-volatile storage element is in a coarse programming
5 mode or a fine programming mode;

performing coarse verification for said non-volatile storage element without
performing fine verification for said non-volatile storage element, if said non-volatile
storage element is determined to be in said coarse programming mode; and

performing fine verification for said non-volatile storage element without
10 performing coarse verification for said non-volatile storage element, if said non-volatile
storage element is determined to be in said fine programming mode.

37. A method according to claim 36, wherein:

said coarse verification and said fine verification are based on a bit line discharge
15 process.

38. A method according to claim 36, wherein:

said non-volatile storage element is a flash memory device.

20 39. A method according to claim 36, wherein:

said non-volatile storage element is a multi-state flash memory device.